Autonomy and AI

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AI: Recent Developments

- Driven by advances in machine learning
  - Deep learning; Big data; Commodity hardware (e.g GPUs, AI processors)
- Strong impact in image recognition, speech understanding, automated translation
- Rapid expansion in other fields
  - Natural sciences, social sciences, engineering, medicine
- Strong investments in industry
  - Google, Facebook, Microsoft, Apple, Samsung, Intel, Adobe
- International expansion (Canada, Europe, China)
- Strong educational demand: undergraduate and graduate

AI at University of Maryland

- Integral part of "Computing at UMD"
  since 1960s

- Strong research groups in computer vision, natural language processing, planning an game theory

- Recent growth in machine learning, robotics, data science

- Strong interest all over the campus
  - STEM fields (natural sciences, engineering)
  - Non-STEM fields (social sciences, humanities, business)

AI at University of Maryland

- Computer vision

- Neuro and swarm computing

- Robotics

- Machine learning

- Natural language processing

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One of the Oldest and Largest Vision Groups in the World

- Founded by Azriel Rosenfeld in 1965.

- By quantitative measures (csrankings.org) #2 group in US, 1998-2018.

- Five computer vision faculty (Aloimonos, Chellappa, Davis, Jacobs, Shrivistava)

- Plus several research faculty (Castillo, Chen, Fermuller, Yacoob),

- Other related faculty (eg., Daume, Duraiswami, Goldstein, Samet, Zwicker),

- ~60 grad students

High Impact Research

- Rosenfeld led foundational work in many early areas of CV, including Relaxation Labeling (3000+ cites).

- Active Vision (1600+ cites), seminal paper in key area of vision.

- Visual Invariants (series of papers launched this subfield of CV).

- Discriminant Analysis for Face Recognition (2000+ cites); remain world leaders in FR.
  - Invention of the year (2 times); work led to FR startup.

- Non-parametric background subtraction (series of 4 papers with 7500+ citations).

- Leafsnap (First app to use CV for species ID, 1.5m downloads, extensive media coverage).
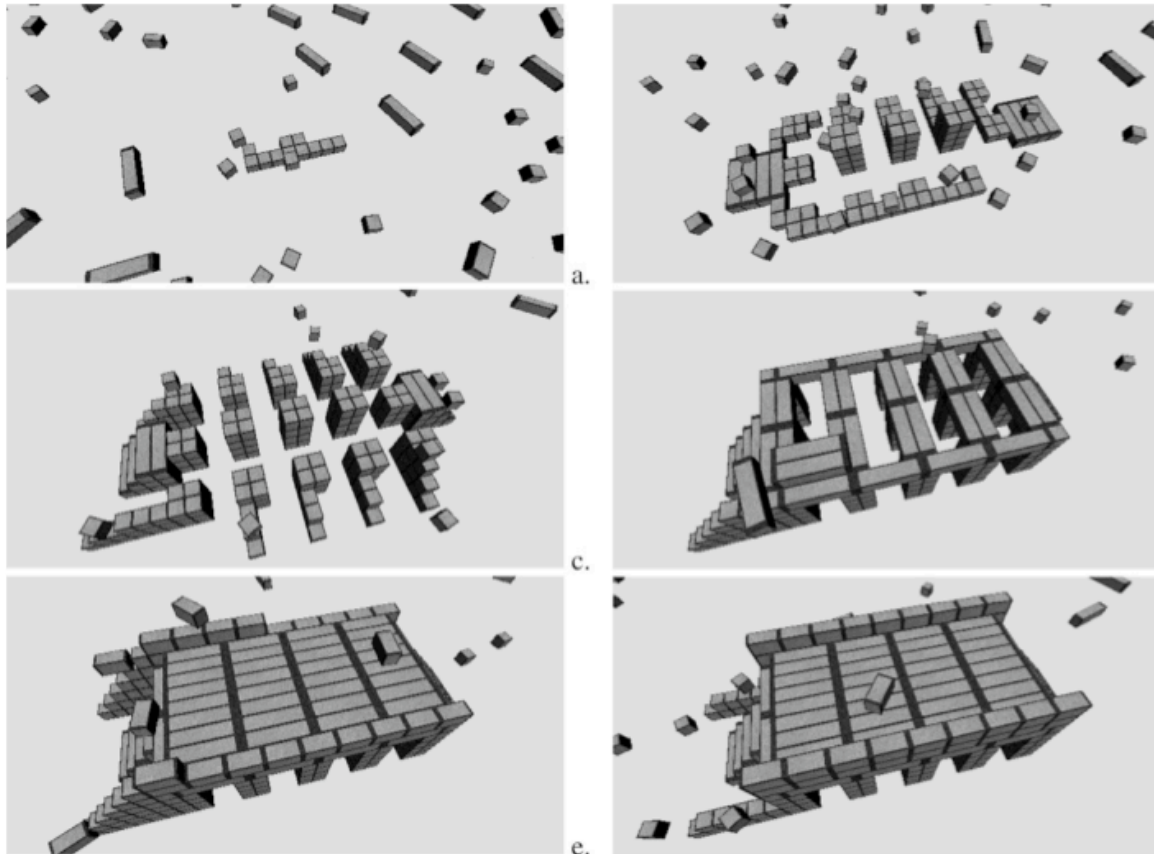
- 10s of millions in funding.

AI at University of Maryland

- Computer vision
- Neuro and swarm computing
- Robotics
- Machine learning
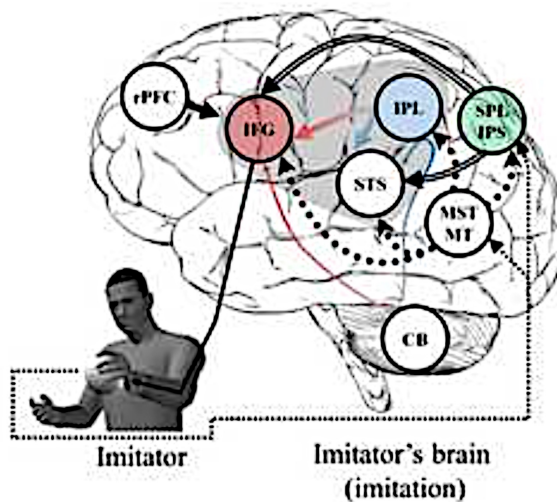- Natural language processing

Swarm Intelligence

Example: self-assembly of components into complex structures (bridge here)
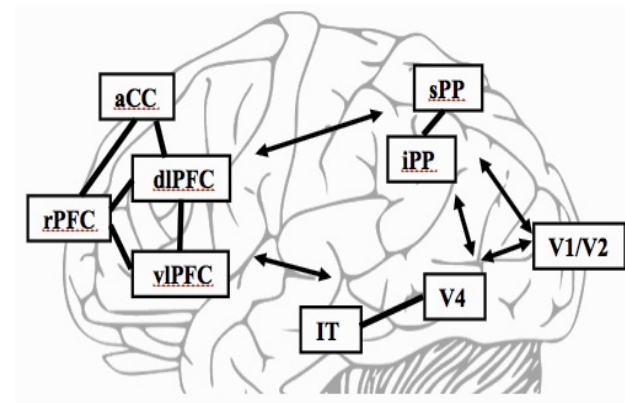
Grushin A, et al., *ACM Trans. Autonomous and Adaptive Systems*, 5, 2010.

Large-Scale Neurocognitive Architectures

imitation learning

Oh H, et al.. *Human Movement Science*, 2018, in press.

cognitive control

Sylvester J, et al.. *Neural Networks*, 79, 2016, 37-52.

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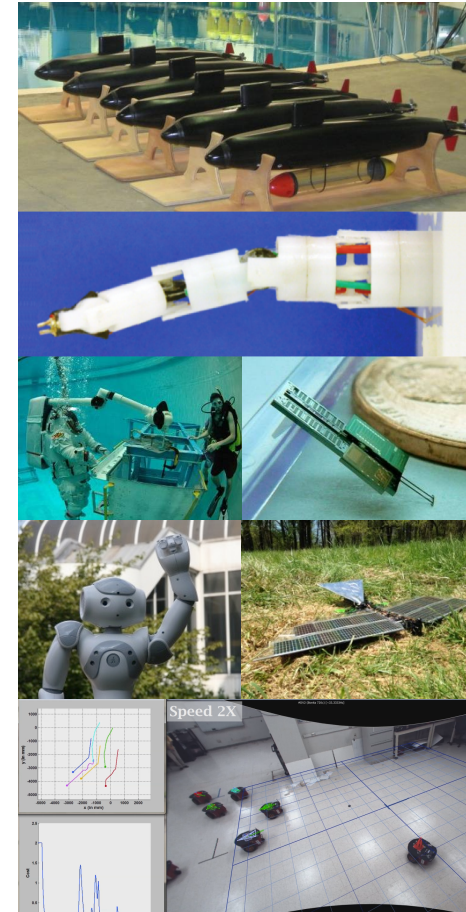
- Machine learning

- Natural language processing

Maryland Robotics Center: Overview

- Housed in the Institute for Systems Research

- Consists of twenty-one labs

- Consists of 40 participating faculty members from eight academic departments

- Current activities cover most facets of robotics

- Educational programs including M. Eng in Robotics

Center Research Expertise

- Bio-Inspired Robotics
- Cognitive Robotics
- Cooperative, Collaborative, Networked Robotics
- Unmanned Vehicles
- Miniature Robots
- Medical Robotics
- Robotics in Extreme Environments
- Social Robotics

Center research projects are supported by the major federal funding agencies including NSF, ARO, ARL, ONR, AFOSR, NIH, DARPA, NASA, and NIST.
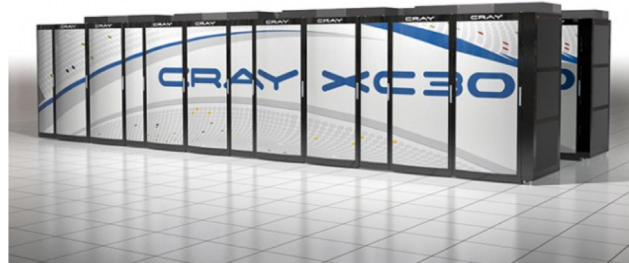
AI at University of Maryland

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- Machine learning

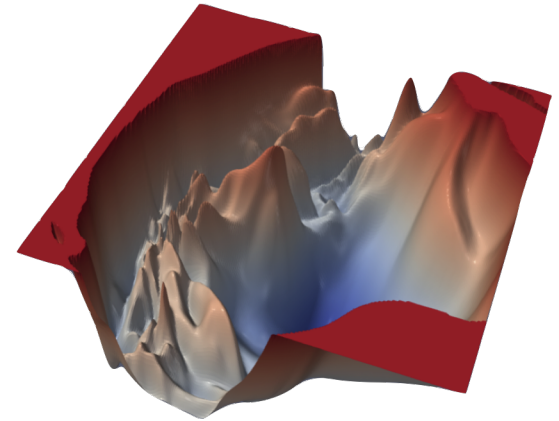- Natural language processing

Machine Learning

Research Areas

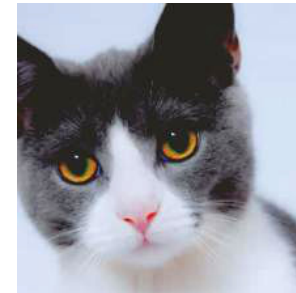**Distributed ML for big data in the cloud**

Understanding Neural Nets

ML on portable low-power devices

Adversarial Learning

"cat"   "traffic light"

- Optimization
- Distributed computing
- Computer vision
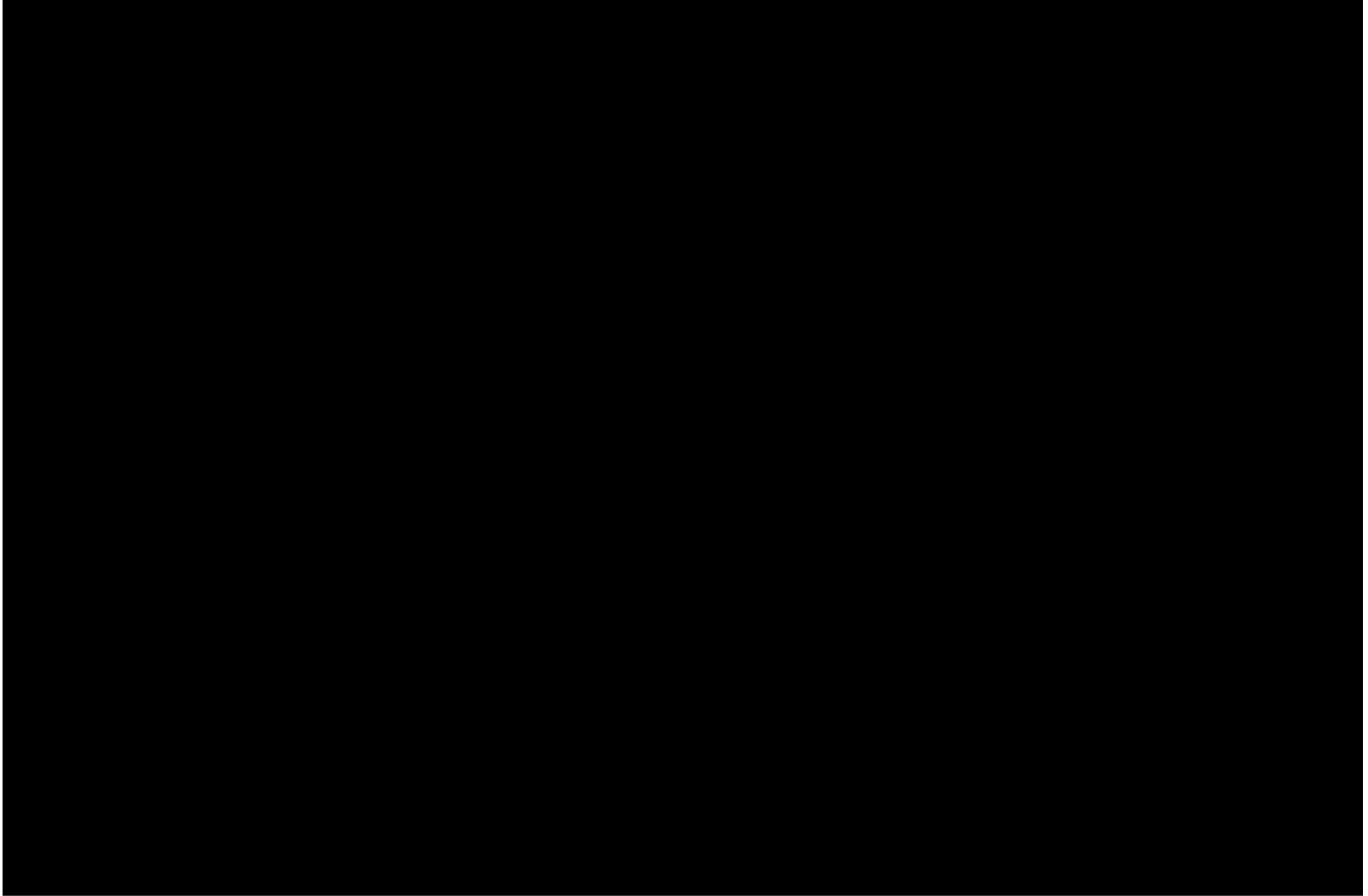- Circuit design

Human-Robot Planning

Real Robot Demo

7-DOF Fetch robot arm

Dynamic motion planning with/without human motion prediction

Natural Language Human-Robot Communication

Robots and Crowds: Realtime Navigation

Automatic navigation
General environments
No precomputation
Simple Lidar sensor

Current AD technology vs. Real-world Scenarios

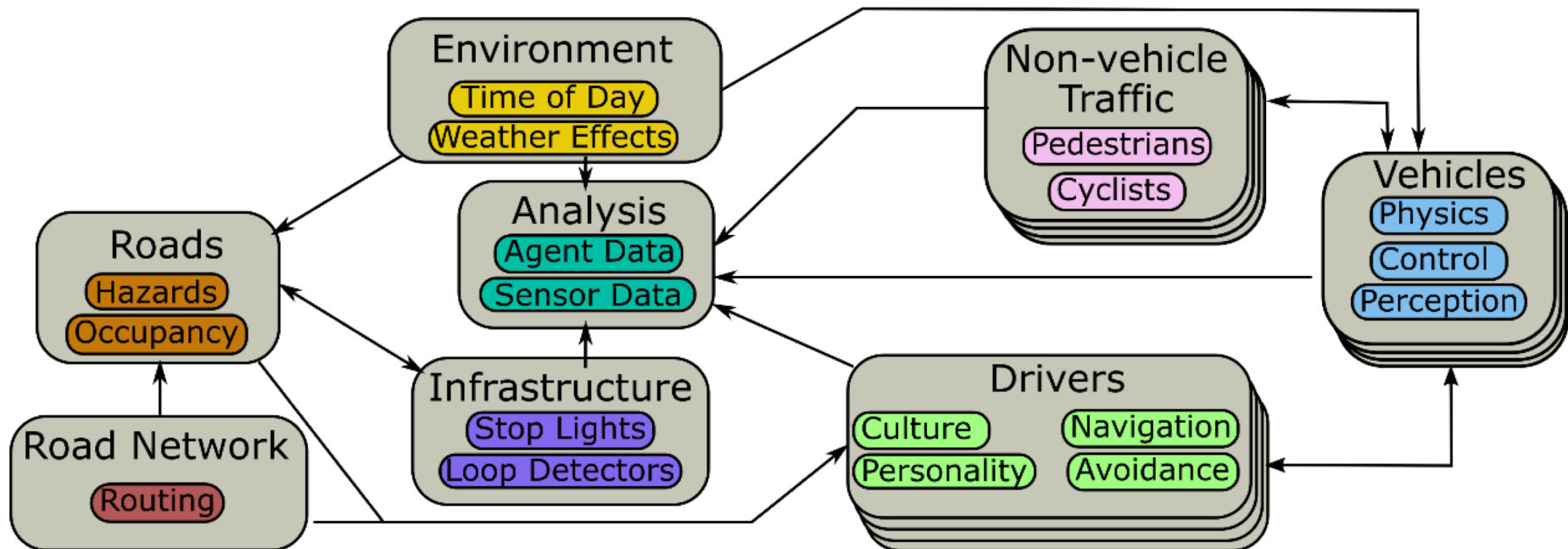- Many traffic situations are still too challenging for autonomous vehicles

Current Autonomous Driving


Urban Traffic Condition

Autonovi-Sim

- Modular simulation framework for generating dynamic traffic conditions, weather, driver profiles, and road networks
- Facilitates novel driving strategy development
- On top of UnReal Engine

Autonovi-Sim: Drivers

- 3 Drivers in AutonoVi-Sim
  - Manual
  - Basic Follower
  - AutonoVi

Drivers

Culture   Navigation
Personality   Avoidance
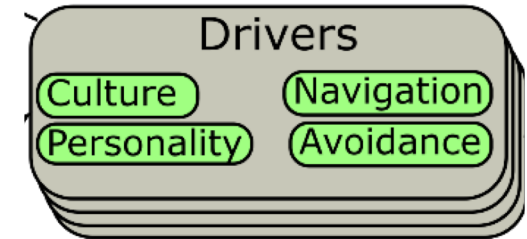
RealTime Traffic Tracking

Agents: Cars, Scooters, Bicycles, Rickshaws, Pedestrians, Animals

Car: Green

Rickshaws: Purple

Pedestrians & Two-Wheelers: Red

Buses: Cyan

Animals: Yellow

Realtime Traffic Prediction

Predicting trajectory of different road-agents; cars, bicycles, pedestrians